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	Prepared by(s) Lisa J. Gelston	Supersedes None
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Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT) Calorimeter

Mass Properties Measurement Procedure

DOCUMENT APPROVAL**Prepared by:**Lisa J. Gelston9/01/04Lisa J. Gelston
CAL Mass Properties Engineer

Date

Approved by:H. L. Scott9/01/04H. Scott
CAL Assembly Manager

Date

Paul V. Dizon9/01/04Paul V. Dizon
CAL Mechanical Subsystem Engineer

Date

J. Eric Grove9/01/04J. Eric Grove
CAL Integration and Test Manager

Date

Naresh Virmani9/01/04Naresh Virmani
CAL Quality Assurance Manager

Date

William C. Raynor9/01/04William C. Raynor
CAL Project Manager

Date

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
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1 INTRODUCTION

1.1 PURPOSE

This document describes the procedure required to measure the mass properties (weight and center of gravity) of the GLAST Calorimeter (CAL) Module.

1.2 APPLICABLE DOCUMENTS

Documents and drawings that are applicable to this procedure are listed below.

LAT-DS-00916	CAL Module
LAT-DS-01224	CAL Pre-Electronics Module
LAT-DS-04536	CAL Tower Module
LAT-DS-04138	CAL Lifting Fixture
LAT-DS-04537	CAL Handling Fixture
LAT-MD-00228	GLAST LAT CAL, TKR, and T&DF Contamination Control Plan
LAT-PS-04237	CAL Module Handling Procedure
LAT-SS-00238	Interface Control Document between the Calorimeter Subsystem and LAT Instrument

1.3 DEFINITIONS AND ACRONYMS

CAL	Calorimeter Subsystem of the LAT
CDE	Crystal Detector Element
CG	Center of Gravity
GLAST	Gamma-Ray Large Area Space Telescope
LAT	Large Area Telescope
PEM	Pre-Electronic Module of the CAL
PR	Problem Record
QA	Quality Assurance
TBD	To Be Defined

2 GENERAL REQUIREMENTS

2.1 MASS PROPERTIES

2.1.1 Mass

The maximum CAL Module mass allocation is 90 kg. The maximum allowable mass variation among CAL modules shall be +/- 2 kg.

2.1.2 CAL Module Center of Gravity

The maximum X/Y center of gravity (CG) offset from the geometric center of a CAL module is +/- 10 mm.

The maximum Z CG position from the CAL-grid interface is 116 mm.

2.2 PERSONNEL

All operations involving weighing and CG measurement shall be performed by a qualified operator knowledgeable in the use of the overhead crane, A-Frame hoist, and CAL Lifting Fixture specified in this procedure. Furthermore, only personnel trained in proper ESD procedures shall be allowed to participate in handling activities.

2.3 ENVIRONMENT

Environmental conditions are defined in the Calorimeter, Tracker, & Data Acquisition Contamination Control Plan, LAT-MD-00228. Depending on the assembly flow of the CAL Tower Module, weighing and CG measurement operations for the CAL Tower Module and Pre-Electronics Module (PEM) will be performed in a clean room environment with the conditions defined below:

- Temperature: 20°C to 25°C
- Relative Humidity: 35% RH to 50% RH
- Cleanliness: Class 100,000 or better

However, some weighing operations, such as weighing of assembly components or weighing of the CAL Tower Module during environmental testing, may not occur in a clean room environment. These operations shall be performed in the following environmental conditions defined below:

- Temperature: 20°C to 25°C
- Relative Humidity:
 - CAL Tower Module 35% RH to 50% RH (50% RH to 55% RH for up to 3 hours)
(Test Article to be bagged where RH requirements cannot be met)
 - Assembly Components No RH requirement
- Cleanliness:
 - CAL Tower Module Test Article to be bagged where Class 100,000 is not available
 - Assembly Components No Cleanliness Requirement. Components must be cleaned before they can be admitted into the Clean Room

The Quality Assurance Engineer will control these conditions on a regular basis. Temperature and humidity shall be monitored continuously, where applicable, and operations shall be halted if conditions fail to meet these requirements.

2.4 OUTGASING AND CONTAMINATION

All materials used during the measurement of the mass properties shall meet the outgassing and contamination requirements specified in LAT-MD-00228. For operations occurring within the clean room, all personnel shall be trained in proper clean room etiquette and wear clean-room garments, including powder-free gloves. For operations outside of the clean room, all personnel shall wear, at a minimum, powder-free gloves during handling.

2.5 HANDLING AND SAFETY

All ESD precautions per NASA-8739.7 will be followed during operations involving the CAL Tower Module, Tower Electronics Module (TEM), and the TEM Power Supply (TPS). ESD precautions are not necessary for operations involving measurement of non-electrical assembly components outside of the clean-room unless these operations are in close proximity to the CAL Tower Module.

Only personnel trained in proper ESD procedures shall be allowed to participate in measurement activities. Personnel wrist straps shall be worn during all handling of the CAL Tower Module, PEM, TEM, and the TPS. These items as well as work tables and fixtures must be grounded to a common point.

Care must be taken so that no equipment or tools are allowed to rest, strike or bump any part of the CAL Module or its components. All loose objects such as pens, pencils, badges, etc, shall be removed from open pockets when working on or around the CAL Module.

All lifting equipment must have a current certified proof load test. During all overhead crane operations, a controlled area must be established to ensure that personnel are clear of the load at all times.

In Section 4 of this document CAUTION and WARNING notes appear. In each case, the note appears above the section or step to which it refers. A CAUTION note describes a condition, which can be detrimental to flight hardware. A WARNING note describes a condition, which can present a risk to personnel.

2.6 EQUIPMENT AND SUPPLIES

The following equipment and supplies are required for the procedure:

- Load Cell – 500 lb capacity, +1 lb resolution, QTY = 5
- Load Cell Reader
- Associated Lifting Hardware
- Calibrated Torque Wrench
- Square drive Hex Bit for the following fasteners
- M4 Socket-Head Cap Screws
- Miscellaneous Hand Tools
- Powder-Free Gloves and Clean Room Garments
- Personal ESD wrist straps and ankle/foot straps
- Lint-Free Wipes and Swabs
- Acetone
- Isopropyl Alcohol

2.7 PARTS LIST

DRAWING NUMBER PART NUMBER	PART DESCRIPTION	QUANTITY
	PEM Assembly Platform	1
LAT-DS-04138	CAL Lifting Fixture Assembly	1
LAT-DS-02795	Hoist Plate, Calorimeter	1
LAT-DS-04537	CAL Handling Fixture Assembly	1
LAT-DS-01524	Base Plate, Handling Fixture	1
LAT-DS-05952	Post, Handling Fixture	4
BN 40112	Screw, Flange Socket-Head, M4 x 0.45 (20 mm L)	16

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3 WEIGHT AND CENTER OF GRAVITY MEASUREMENT PLAN

Measurement of the mass properties for the CAL consists of the following operations:

- Weighing operation for all CAL Modules
- Center of Gravity measurement for one PEM

Because of the assembly flow, the CAL Module will never be in the complete CAL Module configuration until after it is assembled into the CAL Tower Module. Therefore, the weight and CG of the CAL Module cannot be measured directly. Weighing and CG measurement operations can only take place when the CAL is in various configurations during assembly, as shown in Figure 3-1.

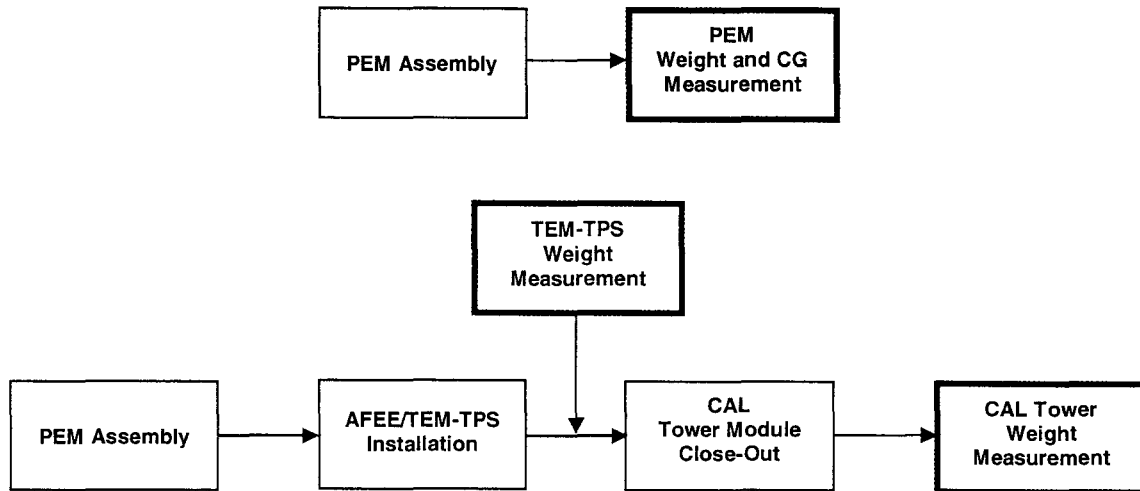


Figure 3-1: Mass Properties Measurement Flow

3.1 WEIGHING OPERATION

Because of the assembly flow, the weight of the CAL Module cannot be measured until after it is already assembled into the CAL Tower Module configuration. Since the weight of the CAL Module cannot be directly measured, all CAL Tower Module components that are not considered part of the CAL Module must be weighed before integration so that an accurate weight of the CAL Module can be determined. These components include:

- Tower Electronics Module - TEM Power Supply Assembly
- Side Panels
- EMI Gaskets
- Associated Fasteners

3.2 CENTER OF GRAVITY MEASUREMENT

Because of the assembly flow, the CG of the CAL Module cannot be measured until the EM2 TEM-TPS is removed from the CAL Module. This event will not take place until after the CAL Module is delivered for integration into the Large Area Telescope (LAT). As a result, the CG of the CAL Module cannot be directly measured. However, it was determined that accurate CG measurements can still be measured when the CAL Module is in the PEM configuration due to the fact that: 1) the missing components only make up 2.5% of the total mass of the CAL Module and; 2) that these components are symmetrically located around the Z-Axis of the CAL Module.

4 PROCEDURE

Measurement of the mass properties for the CAL consists of the following operations:

- Weighing operation for all CAL Modules
- Center of Gravity measurement for one PEM

4.1 WEIGHING OPERATION

Weighing operations are divided into three separate events:

- Weighing of the CAL Tower Module Parts not considered part of the CAL Module
- Weighing of the CAL Tower Module
- Calculation of the CAL Module weight

4.1.1 Weighing of Non-CAL Module Parts:

CAUTION – ESD HAZARD - CAUTION

ESD precautions per NASA-STD-8739 shall be followed

Work Table and Fixtures shall be grounded with 1-10 MOhm Resistor
(QA will verify connection)

Only personnel wearing ESD protection should be present during operations.

1. If applicable according to the ESD Handling and Safety requirements from Section 2.5
 - Verify that a certified grounding strap is connected to the associated electrical component
 - Attach personal wrist strap to a common ground point
2. Weigh the following items and record:

PART NUMBER	PART DESCRIPTION	S/N	QTY	WEIGHT (kg)
LAT-DS-00995	TEM-TPS Assembly		1	
LAT-DS-03844	Support Assembly, AFEE Cable		1	
LAT-DS-03844	Support Assembly, AFEE Cable		1	
LAT-DS-03844	Support Assembly, AFEE Cable		1	
LAT-DS-03844	Support Assembly, AFEE Cable		1	
LAT-DS-03844	Shield, Harness, AFEE Cable		1	
LAT-DS-03844	Shield, Harness, AFEE Cable		1	
LAT-DS-03844	Shield, Harness, AFEE Cable		1	
LAT-DS-03844	Shield, Harness, AFEE Cable		1	
LAT-DS-	AFEE-TEM Harness		1	
LAT-DS-	AFEE-TEM Harness		1	
LAT-DS-	AFEE-TEM Harness		1	
LAT-DS-	AFEE-TEM Harness		1	

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PART NUMBER	PART DESCRIPTION	S/N	QTY	WEIGHT
LAT-DS-	AFEE Card Assembly X		1	
LAT-DS-	AFEE Card Assembly X		1	
LAT-DS-	AFEE Card Assembly Y		1	
LAT-DS-	AFEE Card Assembly Y		1	
LAT-DS-00923	Side Panel, X		1	
LAT-DS-00923	Side Panel, X		1	
LAT-DS-00924	Side Panel, Y		1	
LAT-DS-00924	Side Panel, Y		1	
LAT-DS-02269	Side Panel Gasket		4	
AIC 3353-60-26	Screw, Socket-Head, M6 (30 mm)		4	
N/A	Washer, Flat, M6		4	
19981-SS-0470	Hex M-F Stand-Off, M4 6 mm (32 mm L)		8	
NA0069-040008	Screw, Socket Head Cap, MJ4 x 0.7 (8 mm)		8	
722-95-029-040-0.4B	Washer, Flat, M4		8	
	Cable Ties		12	
NA0068-A025006	Screw, Pan-Head, MJ2.5 x 0.45 (6 mm)		144	
NA0068-A025008	Screw, Pan-Head, MJ2.5 x 0.45 (8 mm)		40	

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4.1.2 Weighing of CAL Tower Module:

The weight of each CAL Tower Module is measured as defined in the following procedural steps:

CAUTION – ESD HAZARD - CAUTION

ESD precautions per NASA-STD-8739 shall be followed

Work Table and Fixtures shall be grounded with 1-10 MOhm Resistor
(QA will verify connection)

Only personnel wearing ESD protection should be present during operations.

WARNING

During Lift Operations, a controlled area must be established to ensure that personnel are clear of the load at all times

1. Verify that a certified grounding strap (with 1-10 MOhm resistor) is connected to the Turn-Over Dolly
2. Attach personal wrist strap to the Turn-Over Dolly
3. Weigh the following items and record:

PART NUMBER	PART DESCRIPTION	S/N	QTY	WEIGHT (kg)
LAT-DS-04138	CAL Lifting Fixture Assembly		1	13.2
LAT-DS-02795	Hoist Plate, Calorimeter		1	13.2 lbs
LAT-DS-04537	CAL Handling Fixture Assembly		1	N/A
LAT-DS-01524	Base Plate, Handling Fixture		1	11.8 lbs
LAT-DS-05952	Post, Handling Fixture		4	4.7 lbs
BN 40112	Screw, Flange Socket-Head, M4 x 0.45 (20 mm L)		16	INCL
N/A	ESD Covers, TEM-TPS		A/R	N/A

4. Verify that PDU/GASU Cables have been disconnected from the TEM-TPS. Install ESD covers over the sockets if they are missing.
5. Attach load cell to hook of the A-Frame hoist
6. Attach the Hoist Ring of the Lifting Fixture Assembly (LAT-DS-04138), minus the Hoist Plate, to the load cell
7. Position the CAL Tower Module underneath the A-Frame and Hoist.
8. Attach CAL Lifting Fixture Hoist Plate (LAT-DS-02795) to the Top Frame of the CAL Tower Module using sixteen M4 socket-head cap screws. Tighten fasteners to 18 in-lb \pm 1 in-lb ;
9. Attach another certified grounding strap to the Hoist Plate
10. Disconnect the grounding strap from the Turn-Over Dolly
11. Lower and attach the Lifting Fixture Assembly onto the Hoist Plate. Reduce the slack in the shackles, but do not load the hoist.

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12. Loosen and remove the 1/2-13 socket-head cap screws securing the Base Plate of the Handling Fixture (LAT-DS-01524) to the Interface Plate (LAT-DS-02858) of the Turn-Over Dolly

13. Using the hoist, slowly lift the CAL Tower Module from the Turn-Over Dolly

14. Record load cell reading from load cell reader in table below:

LIFT	WEIGHT (kg)
1	235.3
2	235.3
3	235.3
Average	235.3

15. Slowly lower the CAL Tower Module until Lifting Fixture Assembly is off-loaded

16. Repeat Step 13 through Step 15 two more times, for a total of 3 separate lifts.

17. Lower the CAL Tower Module, secure the Base Plate of the Handling Fixture (LAT-DS-01524) onto the Interface Plate (LAT-DS-02858) of the Turn-Over Dolly with four 1/2-13 socket-head cap screws. Tighten the fasteners to 30 ft-lb \pm 2 ft lb.

18. Disconnect CAL Lifting Fixture assembly from the CAL Tower Module and store.

4.1.3 Calculation of CAL Module Weight

The weight of each CAL Module calculated using the following worksheet:

PART NUMBER	PART DESCRIPTION	QTY	WEIGHT (kg)
AVERAGE MEASURED WEIGHT FROM SECTION 4.1.2			235.3
TEM-TPS ASSEMBLY SUBTOTAL			16.0
LAT-DS-00995	TEM-TPS Assembly	16.0 lb	
AIC 3353-60-26	Screw, Socket-Head, M6 (30 mm)	0.37 lb	
N/A	Washer, Flat, M6	0.01 lb	
MGSE SUBTOTAL			29.7 lb
LAT-DS-04138	CAL Lifting Fixture Assembly	—	
LAT-DS-02795	Hoist Plate, Calorimeter (STRAPS / SCREWS)	13.2 lbs	
LAT-DS-04537	CAL Handling Fixture Assembly	N/A	
LAT-DS-01524	Base Plate, Handling Fixture	11.8 LB	
LAT-DS-05952	Post, Handling Fixture (QTY 4)	4.7 LB	
BN 40112	Screw, Flange Socket-Head, M4 x 0.45 (20 mm L)	INCL	
N/A	ESD Covers, TEM-TPS	N/A	
CAL MODULE TOTAL			189.6 LB

(86.0 kg)

4.2 CENTER OF GRAVITY MEASUREMENT

The CG location of FM101 is determined by calculation only, and is provided in Excel spreadsheet "CAL FM101 Mass Properties.xls".
CG measurement operations are divided into three separate events:

- Weighing of the PEM about the CG
- Calculation of the PEM CG

The CG is measured on one PEM. The PEM CG location is determined using the following procedural steps:

4.2.1 Measuring Center of Gravity Weight of PEM

CAUTION – ESD HAZARD - CAUTION

ESD precautions per NASA-STD-8739 shall be followed

Work Table and Fixtures shall be grounded with 1-10 MOhm Resistor
(QA will verify connection)

Only personnel wearing ESD protection should be present during operations.

WARNING

During Lift Operations, a controlled area must be established to ensure that personnel are clear of the load at all times

1. Attach the CAL Lifting Fixture Assembly (LAT-DS-04138), minus the Hoist Plate (LAT-DS-02795) onto the hook of the hoist
2. Position the PEM underneath the A-Frame and Hoist.
3. Verify that a certified grounding strap (with 1 – 10 MOhm resistor) is connected to the PEM Assembly Platform
4. Attach personal wrist strap to the PEM Assembly Platform
5. Attach CAL Lifting Fixture Hoist Plate (LAT-DS-02795) to the Top Frame of the PEM using M4 socket-head cap screws. Tighten fasteners to 18 in-lb \pm 1 in-lb
6. Attach another certified grounding strap to the Hoist Plate
7. Attach personal wrist strap to the Hoist Plate
8. Disconnect the certified grounding strap from the PEM Assembly Platform
9. Attach the Lifting Fixture Assembly onto the Hoist Plate. Reduce the slack in the shackles, but do not load the hoist.
10. Loosen and remove the nylon nuts securing the Shear Pins of the PEM onto the Corner Support of the PEM Insertion Tooling (LAT-DS-03321)
11. Using the hoist, slowly lift the PEM from the Base Platform of the PEM Insertion Tooling and verify that the Shear Pins of the PEM are not binding in the holes of the Corner Supports.
12. Lift the PEM above the table and remove all components of the PEM Insertion Tooling
13. Clear PEM Insertion Tooling from the granite table
14. Set up four load cells on the granite table directly underneath the shear pins of the PEM.
15. Using the hoist, slowly lower the PEM onto the four load cells

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16. Record load cell reading from load cell reader in table below:

LIFT	WEIGHT (X, Y) (kg)	WEIGHT (X, Y) (kg)	WEIGHT (X, Y) (kg)	WEIGHT (X, Y) (kg)
1				
2				
3				
Average				

17. Slowly lift the PEM from the load cells until the load cell reader shows a zero reading.
 18. Repeat Step 15 through Step 17 two more times, for a total of 3 separate lifts.
 19. Lift the PEM from the load cells and secure the PEM onto its associated assembly or test fixture
 20. Disconnect CAL Lifting Fixture assembly and store

4.2.2 Calculation of PEM Center of Gravity

The CG of the PEM is calculated using the following worksheets:

LOAD CELL LOCATION	WEIGHT (kg)	X _{CG} (mm)	Y _{CG} (mm)	WT x X _{CG} (kg-mm)	WT x Y _{CG} (kg-mm)
+X +Y					
+X -Y					
-X -Y					
-X +Y					
TOTAL					

$$X_{CG} (PEM) = (WT \times X_{CG})_{TOTAL} / WT_{TOTAL} = \underline{\hspace{2cm}} / \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$$

$$Y_{CG} (PEM) = (WT \times Y_{CG})_{TOTAL} / WT_{TOTAL} = \underline{\hspace{2cm}} / \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$$

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5 QUALITY ASSURANCE

The Quality Assurance (QA) Engineer will ensure that all personnel involved in lifting, handling, and calculation are properly trained to this procedure. It is the responsibility of each individual involved in this operation to report anomalies discovered during in-process weighing to the QA Engineer. The QA Engineer will prepare a Problem Record (PR) and disposition each anomaly appropriately.